PIEZOELECTRIC DRIVE DEVICE

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Applicant:	HITACHI LTD
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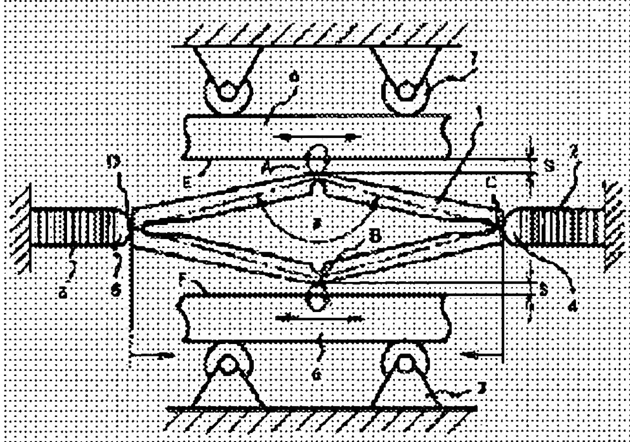
- european:	
Application number:	JP19910282683 19911029
Priority number(s):	JP19910282683 19911029

Abstract of **JP5121790**

PURPOSE:To provide a piezoelectric drive device which continuously drives a drive body by a method wherein the fine vibrations of a piezoelectric element are effectively magnified and converted into elliptical motions. CONSTITUTION:Piezoelectric elements 2 and 3 shifted deviating from each other in phase by an angle of pi/2 are made to act on both ends of an elastic hinge 1 through spherical pressure contacts 4 and 5. By this setup, elliptical motions magnified in major axis at a magnification rate correspondent to an internal angle theta are generated at drive acting points A and B of the elastic hinge 1 to drive moving bodies 6 guided by guide rollers 7. By this setup, as a piezoelectric drive device of this design is simple in structure, easily lessened in size, and able to convert the fine motions of a piezoelectric element into elliptical motions effectively magnifying them, it can be widened in a control range of drive power and speed.



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CLAIMS

[Claim(s)]
[Claim 1] In the piezo-electric driving gear which transmits the oscillation obtained by a driver's consisting of 1 or two or more elastic bodies, and two or more piezoelectric devices, and impressing the periodic electrical potential difference according to individual to said piezoelectric device, respectively to a driven object through said elastic body In the actuation point of application which the structure of said elastic body has the displacement amplification function of a pantograph type, and contacts said driven object The piezo-electric driving gear characterized by compounding an oscillation of said two or more piezoelectric devices to the circumference motion accompanied by amplification of a variation rate, transmitting a part of circumference motion of said actuation point of application to said driven object, and driving it.
[Claim 2] The piezo-electric driving gear with which the structure of said elastic body is the spring structure of a square, a pentagon, or a hexagon with a notch at each top-most vertices, and the interior angle of the top-most vertices of said elastic body makes a part 90 degrees or more actuation point of application in claim 1.
[Claim 3] The piezo-electric driving gear which impresses the sinusoidal voltage or chopping sea electrical potential difference which the phase shifted to said two or more piezoelectric devices in claims 1 or 2, compounds an oscillation of said piezoelectric device to circumference motion of the ellipse or rectangle accompanied by displacement amplification with said elastic body, transmits to said actuation point of application, and said actuation point of application is made to act on said driven side, and drives it.
[Claim 4] The piezo-electric driving gear which have even sets of said driver, and shift the circumference motion period of said actuation point of application of the elastic body in said driver of the moiety by the half period in claims 1, 2, or 3, and each is made to act on said driven object by turns, and is driven.
[Claim 5] The piezo-electric driving gear with which said piezo-electric driving gear is fixed, said driven object is movable in claims 1, 2, 3, or 4 with driving gear, and said piezo-electric driving gear drives said driven object.
[Claim 6] The piezo-electric driving gear which is the advice rail with which said driven object was fixed in claims 1, 2, 3, or 4, and moves by the moving trucking to which said piezo-electric driving gear met said advice rail.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the precise driving gear which requires the precision of the submicron order used for measurement assessment equipments, such as an optical instrument and a surface analysis device.
[0002]
[Description of the Prior Art] The actuation principle of a piezo-electric driving gear drives a mobile continuously, when actuation point of application repeats four following basic actuation successively.
(a) Forcing actuation to the mobile front face of actuation point of application.
(b) Delivery actuation using the frictional force in the condition of having forced actuation point of application to the mobile front face.
(c) Detached building actuation from the mobile front face of actuation point of application.
(d) Return actuation in the condition that actuation point of application separated from the mobile front face.
In order to ensure four above-mentioned actuation, the larger amount of displacement equivalent to the forcing actuation a and the detached building actuation c than parts for displacement loss, such as own surface roughness of a mobile and elastic deformation, must be taken at least. Moreover, also in order to generate big driving force, the amount of displacement of the forcing actuation a is given greatly, and it is necessary to generate big frictional force. It is required to raise the frequency of ellipse motion even to the resonance frequency of the whole driver containing a piezoelectric device on the other hand, in order to enlarge passing speed of a mobile, and to give as greatly as possible the amount of displacement of the delivery actuation b and the return actuation d.
[0003] In these four actuation, in order to carry out efficiently, a high speed and the method of transmitting an oscillation of a piezoelectric device are taken so that actuation point of application may carry out ellipse motion to a mobile front face. And an oscillation of two or more piezoelectric devices from which the deformation direction as shown in drawing 1 or drawing 2 differs combines with a means generate ellipse motion of this actuation point of application, and there is a surface-acoustic-waves method (for example, JP,59-122385,A) which changes into the surface acoustic waves (Rayleigh wave) of an elastic body the supersonic vibration of the oscillating composite system (for example, JP,57-78378,A, a 59-230473 official report) which compounds to ellipse motion of actuation point of application, and drives a mobile, or two or more piezoelectric devices as shown by drawing 3 , and drives a mobile.
[0004] This oscillating composite system is operating deformation of two or more piezoelectric devices independently, respectively, and has the description that the configuration and direction of ellipse motion of actuation point of application are convertible for arbitration. However, the magnitude of the major axis of ellipse motion of actuation point of application or a minor axis is equivalent to the deformation of a piezoelectric device, and since the distortion of a piezoelectric device is at most about 1/1000 also in the piezoelectric device of a laminating mold, it needs to take the large distorted lay

length of a piezoelectric device to take the large amount of displacement of these four actuation. For example, in the piezoelectric device of an about 10mm laminating mold, the amount of displacement of a maximum of 10 micrometers is obtained. Therefore, if it is going to obtain the big amount of displacement, since own resonance frequency of a piezoelectric device falls, the dimension of a piezoelectric device not only becomes large, but the upper limit of an actuation rate will fall.

[0005] Moreover, a surface-acoustic-waves method performs four basic actuation by ellipse motion of the actuation point of application by the surface acoustic waves of an elastic resonance object. Since actuation point of application is obtained only for the number of the surface acoustic waves in the field of the contact surface according to this method, if high pressure is given, it has the description that big driving force can be generated. However, in order to give this high pressure actually to homogeneity in all the fields of the contact surface, it is necessary to double precise processing front faces by the uniform pressure. Furthermore, if a prolonged friction drive is performed, degradation of the surface roughness by wear of the contact surface will take place, the homogeneity of early pressure is lost, and driving force declines. Moreover, since rate-limiting [of the frequency of surface acoustic waves] is carried out to the modulus of longitudinal elasticity of an ingredient, the consistency, and three physical-properties values of a Poisson's ratio other than the configuration of an elastic resonance object, it serves as a big constraint in selection of an ingredient.

[0006]

[Problem(s) to be Solved by the Invention] In order to solve the trouble stated by the Prior art, it is necessary to generate the ellipse motion with the more large amplitude in actuation point of application on a high frequency. That is, in order [which was stated by the Prior art] to ensure delivery actuation and return actuation among four actuation, the larger amount of displacement equivalent to forcing actuation and detached building actuation than parts for displacement loss, such as own surface roughness of a mobile and elastic deformation, must be taken at least. Moreover, also in order to generate big driving force, the amount of displacement of forcing actuation is given greatly, and it is necessary to generate big frictional force. It is required to, raise the resonance frequency of the whole driver which contains a piezoelectric device for the frequency of ellipse motion on the other hand, in order to enlarge passing speed of a mobile, and to give as greatly as possible the amount of displacement of delivery actuation and return actuation. Therefore, in this invention, while offering the structure of the elastic body which the whole driver expands the variation rate of a piezoelectric device efficiently, and can change into ellipse motion of actuation point of application where high resonance frequency is maintained, it aims at offer of the control approach.

[0007]

[Means for Solving the Problem] The configuration of the elastic body for this invention compounding an oscillation of two or more piezoelectric devices to which the periodic driver voltage which shifted the phase is impressed in order to attain this object, and transmitting to a mobile was made into the spring structure of the polygon which has a notch in each top-most vertices, and the interior angle made top-most vertices 90 degrees or more the actuation point of application in contact with a mobile. And especially a desirable gestalt is making the configuration of an elastic body into the spring structure of the square which has a notch in each top-most vertices, a pentagon, or a hexagon.

[0008]

[Function] Since an oscillation of two or more piezoelectric devices with the displacement dilation ratio corresponding to the magnitude of the interior angle of actuation point of application is compoundable with the above-mentioned means, several times as big circumference motion of the actuation point of application of the amplitude as the deformation of a piezoelectric device will be obtained according to very simple structure. Moreover, the configuration and period of circumference motion of actuation point of application are controllable by changing the amount which shifts the wave, frequency, or phase of driver voltage of a piezoelectric device. Therefore, wide range control of the driving force which acts on a mobile, or passing speed is attained.

[0009]

[Example] Hereafter, the example of this invention is explained using drawing. Drawing 1 shows one

example of the piezo-electric driving gear using the elastic hinge of the rhombus by this invention. Piezoelectric devices 2 and 3 are made to act on the power points C and D of the elastic hinge 1 of a rhombus which has a notch in each top-most vertices in drawing 1 through the spherical-surface pressure-welding children 4 and 5, and other end faces of piezoelectric devices 2 and 3 are fixed to a fixed side. On the other hand, a mobile 6 is equipped with two driven sides E and F which counter parallel on both sides of the elastic hinge 1, and is in the location which has the opening S with the actuation point of application A and B of the elastic hinge 1, and degrees of freedom other than the migration direction are restrained by the guide idler 7.

[0010] Next, circumference motion is generated at the actuation point of application A and B of the elastic hinge 1, and by driving piezoelectric devices 2 and 3 on the wave-like fixed electrical potential difference which was able to shift the phase explains how to drive a mobile 6, using drawing. Drawing 2 is drawing having shown how the variation rate which models the structure of the elastic hinge 1 and is given to power points C and D by piezoelectric devices 2 and 3 would be transmitted to the actuation point of application A and B. In drawing 2 (a), the configuration of the elastic hinge 1 of a idle state is set to A, B, C, and D. It is an electrical potential difference V0 to piezoelectric devices 2 and 3, respectively. If the amount of displacement at the time of impressing is set to delta, power points C and D move to the location of C' and D', and the actuation point of application A and B will displace only lambda at right angles to the direction of delta, and they will move it to the location of A' and B'. Here, if the amount delta of displacement is about 1/100 compared with die length of one side of the elastic hinge 1 (for example, distance between A and C), since it can be considered that interior angle theta' after the interior angle theta of the actuation point of application A and B and deformation is the same in approximation, the relation between delta and lambda is expressed with several 1 in approximation.

[0011]

[Equation 1]

lambda=-deltaxtan (theta/2) -- (1) -- if the interior angle theta is 90 degrees or more as shown in several 1, it becomes lambda>delta, and a variation rate will come to be expanded and the interior angle theta will become still larger -- alike -- following -- a variation rate -- a dilation ratio has the property which increases rapidly.

[0012] Moreover, as shown in drawing 2 (b), an electrical potential difference is not impressed to a piezoelectric device 2, but it is an electrical potential difference V0 to a piezoelectric device 3. If it impresses and the amount of displacement is set to delta, it is fixed, and a power point C will move only delta and a power point D will move to the location of C'. In this case, the actuation point of application A and B is displaced only lambda/2 to delta/2 and a perpendicular direction in the direction of delta, and is moved to the location of A' and B'.

[0013] Next, how to impress a sinusoidal voltage to piezoelectric devices 2 and 3 in the example of drawing 1 , and to generate ellipse motion by drawing 3 or drawing 4 at the actuation point of application A and B is explained. Drawing 3 explains how to generate ellipse motion at the actuation point of application A and B, by impressing sinusoidal-voltage V= (V0/2) {sin(omega t+pi / 2)+1} which shifted [sinusoidal-voltage V= (V0/2) {sinomegat+1} which added bias to the piezoelectric device 2] the phase to the piezoelectric device 3 for the applied voltage of a piezoelectric device 2 only pi/2. Drawing 3 (a) shows the applied voltage of piezoelectric devices 2 and 3, and the wave of the amount of displacement of the power points C and D accompanying it here, and drawing 3 (b) shows the deformation process of the elastic hinge 1 every 1/4 period.

[0014] Since a piezoelectric device 2 is extended only delta/2 and the piezoelectric device 3 of the process of 0-1 cringes only delta/2 in drawing 3 (a), the actuation point of application A and B is moved in the direction of the left only delta/2 on this drawing. This process is in the condition from the condition of A4B4C4D4 to A1B1C1D1 in drawing 3 (b), and the actuation point of application A and B is the process of return actuation in the condition of having separated from the mobile front face. Next, since, as for the process of 1-2, a piezoelectric device 2 is extended further only delta/2 and a piezoelectric device 3 is also extended only delta/2 in drawing 3 (a), the actuation point of application A and B is moved in the vertical direction only lambda/2 on this drawing from the relation shown in

several 1. This process is in the condition from the condition of A1B1C1D1 to A2B2C2D2 in drawing 3 (b), and is a process of forcing actuation over the mobile front face of the actuation point of application A and B.
[0015] Next, since the piezoelectric device 2 of the process of 2-3 cringes only delta/2 in drawing 3 (a) and a piezoelectric device 3 is extended further only delta/2, the actuation point of application A and B is moved in the direction of the right only delta/2 on this drawing. This process is in the condition from the condition of A2B2C2D2 to A3B3C3D3 in drawing 3 (b), and is a process of delivery actuation in which the frictional force in the condition of having forced the actuation point of application A and B to the mobile front face was used.
[0016] Next, since the process of a piezoelectric device 2 of 3-4 shrinks further only delta/2 and only delta/2 of a piezoelectric device 3 shrinks in drawing 3 (a), the actuation point of application A and B is moved in the vertical direction only lambda/2 on this drawing. This process is in the condition from the condition of A3B3C3D3 to A4B4C4D4 in drawing 3 (b), and is a process of the detached building actuation from the mobile front face of the actuation point of application A and B.
[0017] By repeating the above four actuation, a major axis performs lambda/2, a minor axis performs delta/2 of ellipse motion, and the actuation point of application A and B drives a mobile in the direction of the right on this drawing. In order to make the direction of this ellipse motion into reverse and to drive a mobile in the direction of the left on this drawing, it is the applied voltage of a piezoelectric device 2 to a piezoelectric device 3. - Sinusoidal-voltage V= (V0/2) {sin(omega t-pi / 2)+1} which shifted the phase only pi/2 is impressed.
[0018] Drawing 4 makes sinusoidal-voltage V= (V0/2) [{2-sin(pi/4)} sinomegat+1] which added bias a fundamental-wave form to a piezoelectric device 2, the electrical potential difference which clamped the minimum to 0 [V] and clamped the upper limit to V0 [V] is impressed, and the electrical potential difference which shifted the phase for the applied voltage of a piezoelectric device 2 only pi/2 is impressed to a piezoelectric device 3. Drawing 4 (a) shows the applied voltage of piezoelectric devices 2 and 3, and the wave of the amount of displacement of the power points C and D accompanying it here, and drawing 4 (b) shows the deformation process of the elastic hinge 1 every 1/4 period. Coming to repeat deformation as shown by drawing 2 (b) by turns, if such a wave-like electrical potential difference is impressed, a major axis performs lambda, a minor axis comes to perform ellipse motion of delta, and the actuation point of application A and B serves as ellipse motion of the magnitude of the two times of the example shown by drawing 3 . Moreover, the Yamagata wave electrical potential difference other than the actuation approach by the sinusoidal voltage as shown in the example of drawing 3 and drawing 4 R> 4 may be used. In this case, the actuation point of application A and B serves as rectangle motion.
[0019] Drawing 5 fixes the actuation point of application B of the elastic hinge of the example shown by drawing 1 in the pivotable condition, and performs deformation of making the distance of the perpendicular direction of power points C and D and the actuation point of application A increase. The actual geometry of the elastic hinge 8 with which drawing 5 (a) performed this deformation, and drawing 5 (b) model the configuration of the elastic hinge 8, and the deformation process at the time of driving piezoelectric devices 2 and 3 by the driver voltage of the gestalt shown in drawing 4 is shown. If the interior angle of theta 1 and the actuation point of application A is set [the distance of the perpendicular direction of the fixed point B and power points C and D / the distance of the perpendicular direction of H, power points C and D, and the actuation point of application A] to theta 2 for the interior angle of nH and the fixed point B here, a major axis will be served as to delta {tan(theta1/2)+tan (theta2/2)} from several one, and a minor axis will serve as abbreviation ellipse motion of ndelta. The advantage of the example shown by drawing 5 can generate still bigger ellipse motion than the example shown by drawing 1 at the actuation point of application A.
[0020] Drawing 6 is an example by the hexagon elastic hinge which transformed into the side the top-most vertices which hit the power points C and D of the elastic hinge of the example shown by drawing 1 , respectively. The actual geometry of the elastic hinge 9 with which drawing 6 (a) performed this deformation, and drawing 6 (b) model the configuration of the elastic hinge 9, and the deformation

process at the time of driving piezoelectric devices 2 and 3 by the driver voltage of the gestalt shown in drawing 4 is shown. Although motion of the actuation point of application A and B becomes the same thing as the example shown by drawing 1 here, since the elastic hinge 9 can be joined to piezoelectric devices 2 and 3 in a field, the elastic hinge 9 can be certainly held by piezoelectric devices 2 and 3.
[0021] Drawing 7 is an example by the pentagon elastic hinge which fixed the base. here -- the side where the pentagon elastic hinge of piezoelectric devices 2 and 3 is parallel -- receiving -- a lever ratio -- it is made to act in the location of 1:n Drawing 7 (a) models the actual geometry of the elastic hinge 10, drawing 7 (b) models the configuration of the elastic hinge 10, and the deformation process at the time of driving piezoelectric devices 2 and 3 by the driver voltage of the gestalt shown in drawing 4 is shown. If it is made this appearance, ellipse motion of the actuation point of application A will be expanded for the scale factor corresponding to a lever ratio.
[0022] In the above, although the generating approach of the ellipse motion by four kinds of elastic hinges has been described, the fundamental application approach as a driving gear is described below. Drawing 8 is the perspective view of the piezo-electric driving gear of the same configuration as the example shown by drawing 1 . Piezoelectric devices 12 and 13 are made to act on the power points C and D of the elastic hinge 11 of a rhombus which has a notch in each top-most vertices in drawing 8 through the spherical-surface pressure-welding children 14 and 15, and other end faces of piezoelectric devices 12 and 13 are fixed to the actuator attachment component 16. On the other hand, a mobile 17 is equipped with two driven sides which counter parallel on both sides of the elastic hinge 11, and is in a location with an opening with the actuation point of application A and B of the elastic hinge 11, and degrees of freedom other than the migration direction are restrained by the guide idler 18. An oscillation is given to piezoelectric devices 12 and 13 by driver voltage as shown by drawing 3 or drawing 4 here, and a mobile 17 is driven by generating ellipse motion in the actuation point of application A and B of the elastic hinge 11.
[0023] Drawing 9 is the perspective view of the piezo-electric driving gear which is equipped with 2 sets of actuators which consist of the elastic hinge 11 and piezoelectric devices 12 and 13 of the example shown by drawing 8 , carries out the half period shift of the ellipse motion of each actuation point of application, is made to act on a mobile 17, and is driven. In order for the actuation point of application of one of the elastic hinges 11 to always act on a mobile 17 by making it such a configuration, driving force and an actuation rate become two times theoretically.
[0024] Drawing 10 is the perspective view of the piezo-electric driving gear of a method which an actuator moves along with the fixed guide rail by the same actuation approach as the example shown by drawing 9 . The actuator which changes from 1 or 2 sets of elastic hinges 11, and piezoelectric devices 12 and 13 to the actuator attachment component 16 which installed the guide idler 19 in drawing 10 is fixed. A guide rail 20 is equipped with two driven sides which counter parallel on both sides of the slideway and the elastic hinge 11 of a guide idler 19. Since it becomes the migration which became what was suitable for migration of a big stroke by making it such a configuration, and met the orbit of a guide rail, migration of a curvilinear orbit is also attained.
[0025] Deformation on structure which uses as a movable side plurality-izing of an actuator which explained by drawing 9 and drawing 10 , and an actuator can be similarly performed about the example shown by drawing 5 R> 5, drawing 6 , and drawing 7 , and the same effectiveness can be acquired.
[0026]
[Effect of the Invention] The piezo-electric driving gear of this invention is easy structure, and easy to miniaturize, and since an oscillation of two or more piezoelectric devices is efficiently expanded to ellipse motion and can be compounded, the control range of driving force and an actuation rate becomes large.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The explanatory view of the example of the piezo-electric driving gear using the elastic hinge of the rhombus by this invention.
[Drawing 2] The explanatory view of the deformation condition of the elastic hinge of a rhombus shown in drawing 1 .
[Drawing 3] The driver voltage wave of a piezo-electric driving gear and the explanatory view of the deformation process of an elastic hinge which were shown in drawing 1 .
[Drawing 4] The driver voltage wave of a piezo-electric driving gear and the explanatory view of the deformation process of an elastic hinge which were shown in drawing 1 .
[Drawing 5] The block diagram of the example of the piezo-electric driving gear using the rhombus elastic hinge which fixed one actuation point of application by this invention, and the explanatory view of the deformation process.
[Drawing 6] The explanatory view of the deformation process of the example of the piezo-electric driving gear using the elastic hinge of the hexagon by this invention.
[Drawing 7] The block diagram of the example of the piezo-electric driving gear using the five-cornered elastic hinge which fixed the one side by this invention, and the explanatory view of the deformation process.
[Drawing 8] The perspective view of the example of adaptation of the piezo-electric driving gear shown in drawing 1 .
[Drawing 9] The perspective view of the example of adaptation equipped with 2 sets of actuators in the piezo-electric driving gear shown in drawing 1 .
[Drawing 10] The perspective view of the example of adaptation which used the actuator as the movable side in the piezo-electric driving gear shown in drawing 1 .
[Description of Notations]
1 [-- A mobile, 7 / -- Guide idler.] -- 2 An elastic hinge, 3 -- 4 A piezoelectric device, 5 -- A spherical-surface pressure-welding child, 6

[Translation done.]

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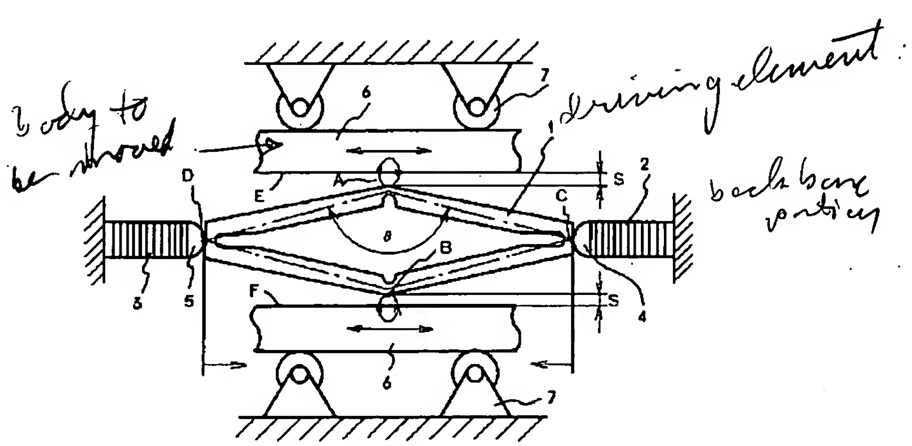
DRAWINGS

[Drawing 1]

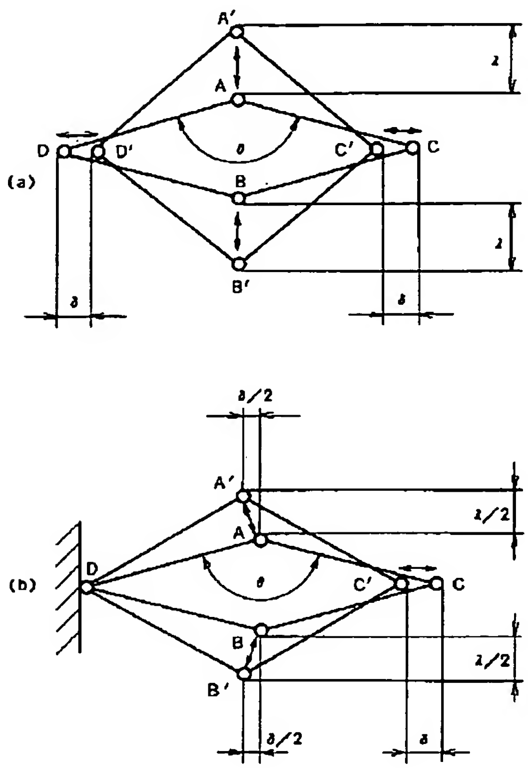
図 1



1 ……… 弾性ヒンジ　　6 … 移動体
2，3 … 圧電素子　　7 … ガイドローラ
4，5 … 球面圧接子

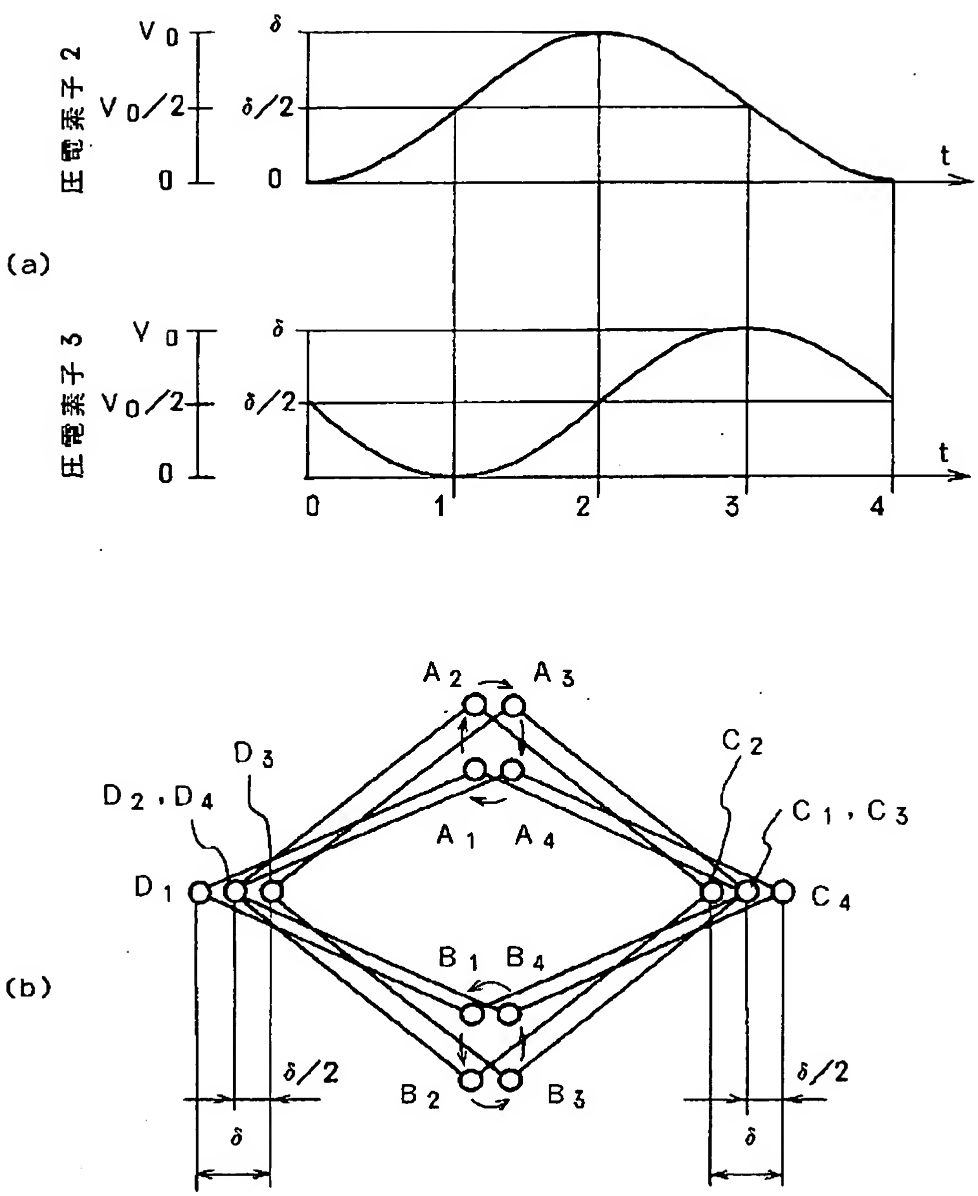
[Drawing 2]

図 2



[Drawing 3]

図 3



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δ/2
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δ
δ/2
t
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2
3
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A 3
D 3
C 2
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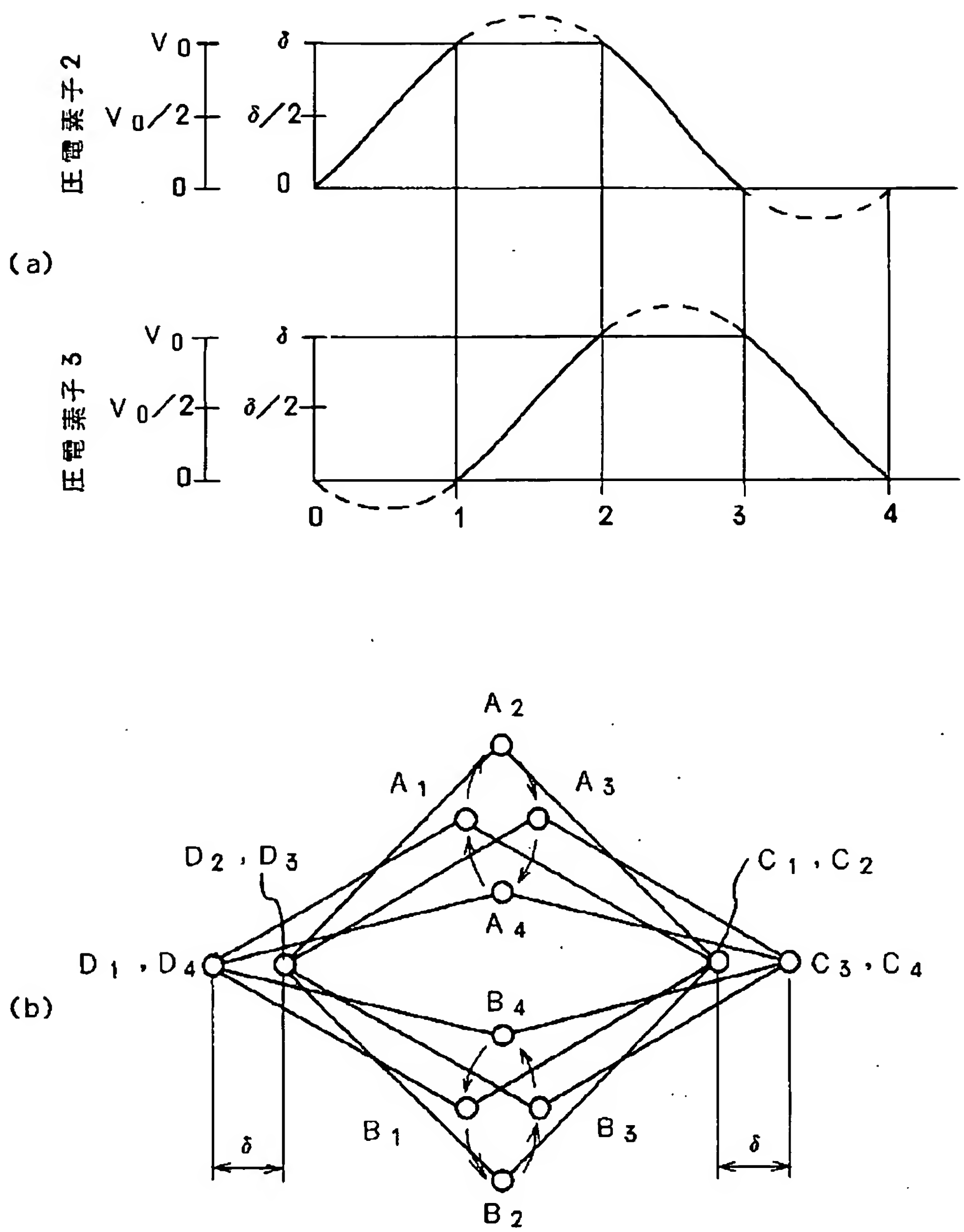
[Drawing 4]

図 4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A3
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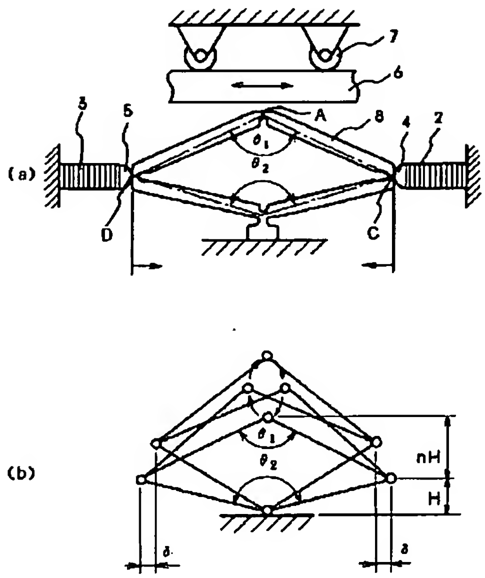
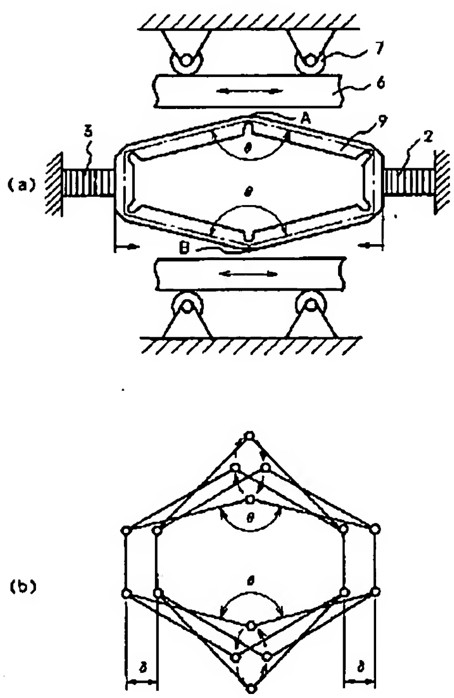
[Drawing 5]

図 5



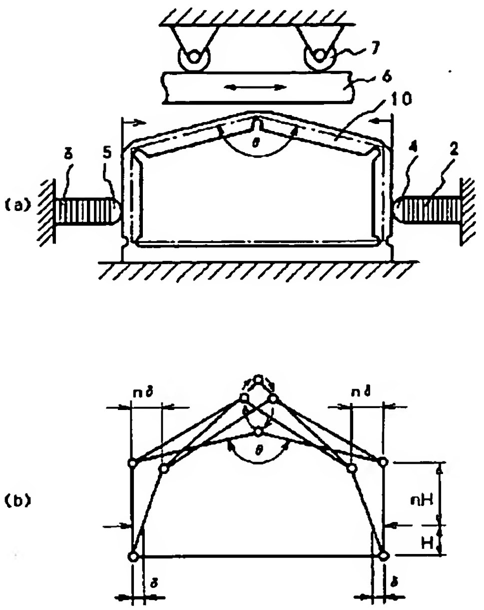
[Drawing 6]

図 6



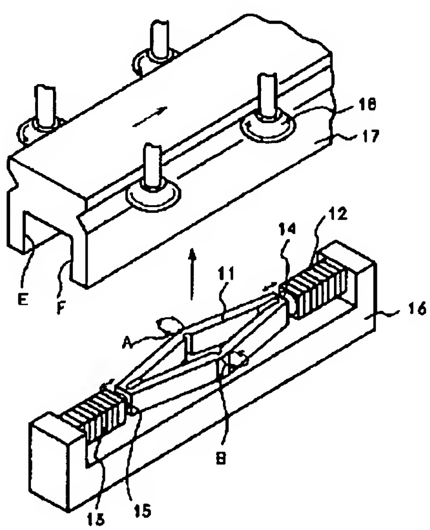
[Drawing 7]

図 7



[Drawing 8]

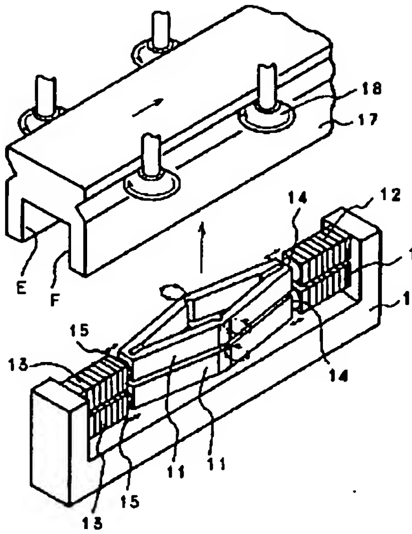
図 8



11……… 弾性ヒンジ
12, 13 … 圧電素子
14, 15 … 球面圧接子
16 … 駆動部保持部材
17 … 移動体
18 … ガイドローラ

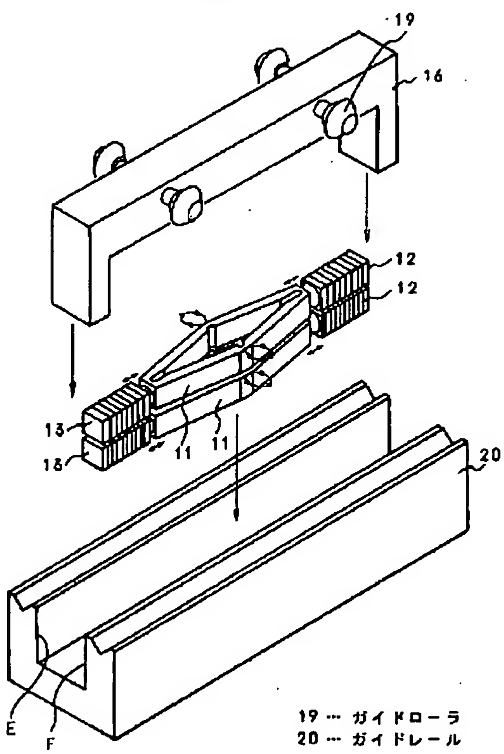
[Drawing 9]

図 9



[Drawing 10]

図 10



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